Cretaceous Research 52 (2015) 108–117

Contents lists available at ScienceDirect

Cretaceous Research

journal homepage: www.elsevier.com/locate/CretRes

New dragonflies from the lower Cenomanian of France enlighten the timing of the odonatan turnover at the Early – Late Cretaceous boundary

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ARTICLE INFO

Article history:
Received 10 June 2014
Accepted in revised form 21 August 2014
Available online 3 October 2014

Keywords:
Insecta
Anisoptera: Cavilabiata
Stenophlebioptera
Family
gen. et sp. nov.
Cenomanian faunistic turnover

ABSTRACT

Three early Cenomanian Odonata are described from France (Jaunay-Clan locality, Vienne), i.e. the aeshnoid *Galloliupanshania incompleta* gen. et sp. nov. in the Liupanshaniidae, the libelluloid *Gallophlebia magnifica* gen. et sp. nov. in the new family Gallophlebiidae closely related to the Early Cretaceous Araripephlebiidae, and *Gallostenophlebia incompleta* gen. et sp. nov., as the youngest record of the clade Stenophlebioptera: Stenophlebiidae. *Gallophlebia* is a new case showing the high diversification of the libelluloid clade during the Cretaceous, while *Gallostenophlebia* corresponds to one of the last "survivors" of the odonatan ancient lineages in relation to the faunistic turnover around the Early–Late Cretaceous boundary.

1. Introduction

The Early–Late Cretaceous boundary is a crucial period for the evolution of the class Insecta. Groups like ants or bees that are keystones in the Cenozoic and modern ecosystems diversified at this time (around 100 Myr) (LaPolla et al., 2013). Last and most recent representatives of numerous clades are recorded during the Cenomanian, suggesting several extinction and diversification events. It is especially the case for the insects that are related to aquatic environments (Fleck and Nel, 2003). Because they have one of the best fossil record, the study of the changes that have occurred in the order Odonata is of great interest to analyse these phenomena. At this stage of the art of the recent data, it is possible to assert that several major clades of subordinal rank are not recorded and were probably extinct after the Cenomanian while they were flourishing in the Early Cretaceous. It is the case for the Tarsophlebiidae, the Isophlebioptera, the Heterophlebioptera, and the Stenophlebioptera (clades that were considered in the assemblage "Anisozygoptera" of the ancient authors) (Fleck et al., 2003, 2004), and especially for the very diverse family Aeschnidiidae whose last known representative is Cenomanian in age (Fleck and Nel, 2003). By contrast, the earliest known representative of one of the most diverse modern family Libellulidae is Turonian in age (Fleck et al., 1999). Therefore, it seems that at least some modern clades diversified during and by the Cenomanian and 'replaced' these more 'ancient' groups. This hypothesis would need a confirmation through a better knowledge of the Late Cretaceous odonatofauna. If the fossil record of these insects is well documented from the Early Cretaceous, it is clearly not the case from the Cenomanian and onwards. For instance, there is a single record of a dragonfly in the French Cenomanian with the locality Puy Puy, representing a strange family of Aeshnoptera (Nel et al., 2008). Thus, any new discoveries of Odonata from the Late Cretaceous will add important information on the dating and process of this great faunistic change. Thanks to new field researches made in the ephemeral locality of Jaunay-Clan located along the future line of "LGV SEA" high speed railway between Paris and Bordeaux, three well-preserved wings of Odonata were discovered,

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http://dx.doi.org/10.1016/j.cretres.2014.08.005
0195-6671/

representing an Aeshnoptera, a new "libelluloid" family and the youngest representative of the Stenophlebioptera.

2. Material and methods

The new locality of Jaunay-Clan (Valentin et al., 2014) is located close to the city of Poitiers, in the south-western part of the Paris Basin, Vienne department, western France. It was discovered during prospections conducted by the association Palaios, following an agreement with the companies LISEA and COSEA (VINCI group). Three fossil localities (Fig. 1A) were spotted from lower Cenomanian laminated lignitic mudstones. Abundant plant assemblage including ferns (*Cladophlebis*, *Osmundophyllum*, *Ruffordia goeppertii*, *Sphenopteris*), conifers (*Brachyphyllum*, *Dammarophyllum*, *Pagiophyllum*) and angiosperms (*Eucalyptolaurus depreii*, *Ploufolia*) was collected from the locality of Jaunay-Clan Ormeau-Saint-Denis (JCO), and indicates a freshwater pond-like environment. The insect remains (odonatan wings and coleopteran specimens) were concentrated and come from one of the sedimentological border depressions (Fig. 1B). All the studied materials are housed and catalogued in the collections of the University of Poitiers.

Line drawings of the venation patterns of selected specimens were drawn directly with the aid of a camera lucida. Photographs were taken using a Canon D550 digital camera with MP-E 65 mm and EF 50 mm lenses. Original photographs were processed using the image-editing software Adobe Photoshop CS.

We follow the wing venation nomenclature of Riek and Kukalová-Peck (1984), amended by Nel et al. (1993) and Bechly (1996). The higher classification of fossil and extant Odonatoptera, as well as familial and generic characters followed in the present work are based on the phylogenetic system proposed by Bechly (1996, 2014) amended by Fleck (2011). Wing vein abbreviations are as follows: ScP subcosta posterior, RA radius anterior, RP radius posterior, IR intercalary radial veins, MA median anterior, MP median posterior, CuA cubitus anterior, CuP cubitus posterior, AA analis anterior, N nodus, Cr nodal crossvein, Sn subnodus, d.c discoidal triangle, t.p. trigonal planate, a.l. anal loop, Aspl1 analis supplementary 1, Pt pterostigma.

3. Systematic palaeontology

Superorder Odonatoptera Martynov, 1932
Infrasuperorder Panaisoptera Bechly, 1996
Order Anisoptera Selys, 1854
Suborder Aeshnoptera Bechly, 1996
Family Liupanshaniidae Bechly et al., 2001
Genus *Galloliupanshania* gen. nov.

Derivation of name. Named after Gallia, Latin name for the country France and Belgium, and the genus name *Liupanshania*. Gender feminine.

Type species: Galloliupanshania incompleta sp. nov.

Diagnosis. Hind wing characters only. RP1 and RP2 basally parallel up to pterostigma, with only one row of cells between them; RP3/4 and MA weakly undulating, closely parallel up to posterior wing margin with only one row of cells between them; Rspl and Mspl absent; RP2 not undulating; a very strong convex trigonal planate together with a strong angle of MAb; MAb

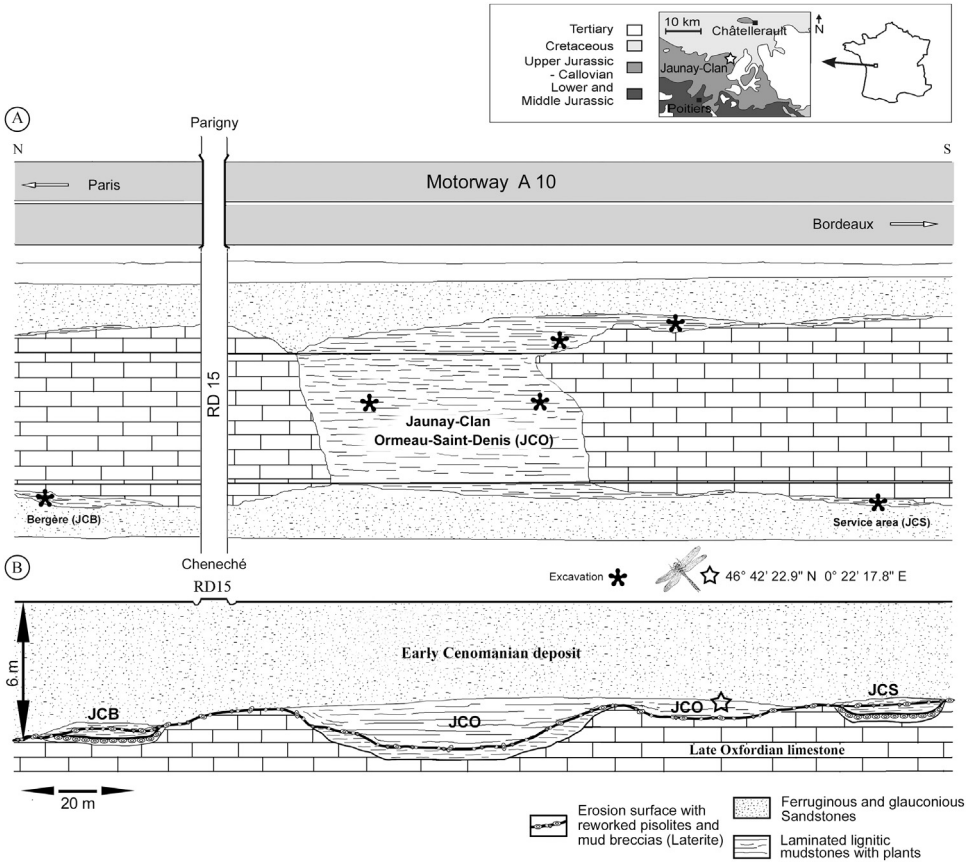

Fig. 1. Geological setting and location of the locality Jaunay-Clan. A. Drawn profile of the three localities: Bergère (JCB), Ormeau-Saint-Denis (JCO) and Service area (JCS). B. Stratigraphic section.